



## Five years later: Recovery from post traumatic stress and psychological distress among low-income mothers affected by Hurricane Katrina

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### ABSTRACT

Hurricane Katrina, which struck the Gulf Coast of the United States in August 2005, exposed area residents to trauma and extensive property loss. However, little is known about the long-run effects of the hurricane on the mental health of those who were exposed. This study documents long-run changes in mental health among a particularly vulnerable group—low income mothers—from before to after the hurricane, and identifies factors that are associated with different recovery trajectories. Longitudinal surveys of 532 low-income mothers from New Orleans were conducted approximately one year before, 7–19 months after, and 43–54 months after Hurricane Katrina. The surveys collected information on mental health, social support, earnings and hurricane experiences. We document changes in post-traumatic stress symptoms (PTSS), as measured by the Impact of Event Scale-Revised, and symptoms of psychological distress (PD), as measured by the K6 scale. We find that although PTSS has declined over time after the hurricane, it remained high 43–54 months later. PD also declined, but did not return to pre-hurricane levels. At both time periods, psychological distress before the hurricane, hurricane-related home damage, and exposure to traumatic events were associated with PTSS that co-occurred with PD. Hurricane-related home damage and traumatic events were associated with PTSS without PD. Home damage was an especially important predictor of chronic PTSS, with and without PD. Most hurricane stressors did not have strong associations with PD alone over the short or long run. Over the long run, higher earnings were protective against PD, and greater social support was protective against PTSS. These results indicate that mental health problems, particularly PTSS alone or in co-occurrence with PD, among Hurricane Katrina survivors remain a concern, especially for those who experienced hurricane-related trauma and had poor mental health or low socioeconomic status before the hurricane.

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### Introduction

Hurricane Katrina struck the Gulf Coast of the United States on August 29, 2005, producing widespread property loss and exposing numerous citizens to traumatic experiences. New Orleans residents were particularly hard-hit. Not only did the storm produce direct damage, but also levee breaks created extensive flooding that led to the exodus of residents from the city. Those who did not return had to build lives in new locations; those who returned had to contend with a severely damaged city and, in many cases, homes and neighborhoods that had been devastated.

The adverse effects of Hurricane Katrina on the mental health of Gulf Coast residents became apparent shortly after the storm.

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Assessments of evacuees indicated that many were experiencing symptoms of emotional distress (Brodie, Weltzien, Altman, Blendon, & Benson, 2006; Mills, Edmondson, & Park, 2007). Displaced residents who were interviewed early in 2006 also exhibited high, distress levels (Abramson, Stehling-Ariza, Garfield, & Redlener, 2008). Studies conducted in the year after the hurricane continued to indicate that hurricane exposure was associated with mental health problems. A population-based study conducted during this time period indicated that individuals who had lived in the affected Gulf Coast area had elevated levels of psychological distress but, surprisingly, lower-than-expected levels of suicidality (Kessler, Galea, Jones, & Parker, 2006). Another study followed a sample of displaced or greatly affected individuals from 6 to 12 months after the hurricane, to 20–24 months after the hurricane, and found high levels of mental distress that did not decline between the two surveys (Abramson et al., 2008). These results are

broadly consistent with studies of other large-scale natural disasters (Bourque, Siegel, Kano, & Wood, 2006; Frankenberg et al., 2008; Galea, Nandi, & Vlahov, 2005; Norris et al., 2002, Part I; Norris, Friedman, & Watson, 2002, Part II).

This study examines the long-run mental health consequences of Hurricane Katrina for a sample of low-income mothers who lived in New Orleans at the time of the hurricane. Earlier research using this sample found that they displayed high levels of psychological distress (PD) and post-traumatic stress symptoms (PTSS) between 7 and 19 months after the storm (Rhodes et al., 2010). Using data from a re-survey of this sample 43–54 months after Hurricane Katrina, we document changes in symptoms of PTSS, PD, and the co-occurrence of PTSS and PD, and study the determinants of mental health trajectories.

Our results contribute to an understanding of how vulnerable populations have fared since Hurricane Katrina. Although our sample is not representative of the New Orleans population before the hurricane, it is of particular interest given the large literature that indicates that women, parents, and those who are economically disadvantaged are at particular risk of developing PTSD and other mental health problems after natural disasters (Galea et al., 2005; Norris et al., 2002, Part I; Norris et al., 2002, Part II). Within this context, we sought to identify both the pre-hurricane resources, such as higher socioeconomic status and better mental health, associated with faster recovery, and the hurricane-related experiences associated with a more delayed recovery.

Although members of this group may be vulnerable, there is substantial variation in their post-disaster mental health outcomes. For the purposes of targeting treatment, it is important to understand why some are resilient and others are not. A significant feature of our sample is that, because members were recruited before the hurricane, we could examine how pre-hurricane mental health, social support, earnings and family composition influence recovery trajectories. Because of the unpredictable nature of disasters, very few studies have information on mental health before the disaster, so researchers cannot determine whether and when individuals have returned to their “pre-disaster” levels of psychological functioning. They also do not include information on factors such as pre-disaster social support, which may be important in preventing mental health problems but is difficult to measure after-the-fact. In what follows, we compare the results of our work with those of other longitudinal studies of Hurricane Katrina (Abramson et al., 2008; Kessler et al., 2008; Sastry & VanLandingham, 2009). While these studies have the advantage of representative samples, they lack longitudinal information that spans the hurricane.

In addition to providing information about Hurricane Katrina, this study makes several contributions to the larger literature on the mental health effects of natural disasters. First, it provides information on the longer-run effects of natural disasters on mental health and, more specifically, the factors that influence recovery trajectories. Relatively few longitudinal studies track the course of mental health problems over prolonged periods of time after natural disasters. A 2005 review of the epidemiology of post-traumatic stress noted that the handful of existing longitudinal studies of natural disasters document varied recovery patterns, with some individuals recovering quickly, others developing chronic problems, and some experiencing a delayed onset of symptoms (Galea et al., 2005). Long-term and even delayed symptoms might be due to the fact that natural disasters may produce prolonged and continuing hardship due to property loss, the death of family or friends, and disruptions in living arrangements. Hurricane Katrina, which produced both immediate traumatic experiences and long-term hardship, provides a useful vehicle to examine how these experiences influence mental health trajectories.

A second contribution of this study is that it examines how pre-hurricane and post-hurricane factors separately influence PD, PTSS, and their co-occurrence. The literature on the course of mental health outcomes following natural disasters has given relatively little attention to whether different psychological problems, such as post-traumatic stress, depression and suicidality, follow different trajectories and are influenced by different factors. Some evidence indicates that this is indeed the case. One study of the effects of Hurricane Andrew over 30 months found that depression remained stable, and some components of post-traumatic stress increased whereas others declined (Norris, Perilla, Riad, Kaniasty, & Lavizzo, 1999). This study concluded that less persistent psychological problems were more strongly associated with the experiences of the disaster itself, whereas more persistent problems were more strongly associated with post-disaster stressors. Other studies have noted that anxiety and mood disorders frequently co-occur with post-traumatic stress after disasters: a study of the short-term consequences of Hurricane Katrina found that *all* individuals from New Orleans who were classified as having PTSD also had anxiety-mood disorder (Galea et al., 2007). Because our data contain measures of both PD and PTSS at two points in time, we were able to examine (for example) whether some factors lead to PTSS that gives way to PD, whereas others predict chronic co-occurring PTSS and PD. This nuanced understanding of the determinants of the course of mental health after a major natural disaster may prove useful in targeting appropriate treatment.

## Methods

The sample was drawn from the *Opening Doors* study in New Orleans. Conducted by MDRC, *Opening Doors* was a multi-site national study of performance in community college among low-income adults (Richburg-Hayes et al., 2009). The *Opening Doors* program in New Orleans differed from programs elsewhere, in that eligibility was restricted to low-income parents. Between November 2003 and February 2005, the study enrolled 942 women and 77 men when they registered for courses at one of three campuses in New Orleans. This produced a sample consisting primarily of African-American mothers, many of whom were welfare recipients, who were older than typical college students. Given the small number of men in the study, we focused exclusively on women.

### Data collection

The 942 women completed a baseline questionnaire at the time of enrollment, which collected information about socioeconomic status and health, and included an assessment of PD. All respondents signed a consent form at enrollment. The study was approved by the Princeton Institutional Review Board.

The first post-hurricane follow-up study, conducted between March 2006 and March 2007, surveyed 667 of the original 942 female respondents (70.8% response rate) by telephone. A second follow-up survey was administered to 720 women (76.4% response rate) between March 2009 and April 2010. These surveys collected information on mental health and individuals' experiences during and after the hurricane. A total of 568 women (60.3%) completed both follow-up surveys. We excluded 9 respondents who moved away from New Orleans between the baseline survey and the hurricane, and another 27 who did not complete all psychological scales we used in our analysis. The final sample size was 532.

The respondents experienced high mobility after the hurricane. At the second follow-up, they lived in 23 states; only 16% resided in their pre-hurricane homes. Given this extraordinary mobility, the response rates that were obtained are remarkably high. In addition, cooperation was high: only 35 women refused to take the second follow-up.

## Measures

We examined two outcomes: post-traumatic stress symptoms (PTSS) as measured by the Impact of Event Scale-Revised (IES-R), and symptoms of non-specific psychological distress, as measured by Kessler's K6 scale.

The IES-R and its precursor, the Impact of Event Scale (IES), have been used in numerous studies of the effects of natural disasters (Weems et al., 2007; Weiss & Marmar, 1997; Zilberg, Weiss, & Horowitz, 1982). The IES-R is a 22-item self-report scale that assesses distress produced by a specific traumatic event. It was developed to cover all DSM IV criteria for post-traumatic stress disorder (PTSD). Although the IES-R does not provide a clinical diagnosis, studies of the psychometric properties of the IES-R indicate that it can identify individuals who are at high risk of meeting the diagnostic criteria for PTSD (Creamer, Bell, & Failla, 2003). The IES-R asks respondents to rate how much they were bothered by symptoms of distress about a traumatic event over the previous 7 days. Responses are coded from 0 ("never") to 4 ("extremely"). Scores are averaged over items, producing a total score that ranges from 0 to 4. Earlier research indicates that individuals with IES-R scores exceeding 1.5 are at high risk of having PTSD (Creamer et al., 2003). We used this cut-off to define PTSD.

The K6 is a widely-used self-report scale that measures non-specific psychological distress and is used to screen for anxiety and mood disorders (Furukawa, Kessler, Slade, & Andrews, 2003; Kessler et al., 2010). It has been used in several other studies of Hurricane Katrina, permitting cross-study comparisons. The 6 items of the scale ask about feelings such as "hopelessness" experienced during the past 30 days, with responses coded from 0 ("none of the time") to 4 ("all of the time"). The total score is the sum of the item scores. Previous validation studies indicate that scores of 8–12 indicate probable mild to moderate mental illness (MMI), and scores of 13–24 indicate probable serious mental illness (SMI). In most of our analyses, we combine probable mild to moderate mental illness and probable serious mental illness into a single category of "psychological distress" (PD).

The covariates in our analyses included a set of variables measured at baseline: monthly earnings in the current or most recent job, an indicator of PD (based on the K6), and a measure of perceived social support (Cutrona & Russell, 1987). The 8-item social support scale asked respondents the degree to which they agreed with statements such as "I have a trustworthy person I can turn to if I have problems." Each item was coded from 1 to 4, with higher values corresponding to greater social support. The item scores were averaged to obtain a total score. Respondents completed the K6 at baseline, and we classified an individual as having poor mental health at baseline if she had a K6 score that exceeded 7. Covariates also included the age of the respondent at the time of the hurricane, and measures of family composition just before the hurricane: an indicator that the respondent lived with a spouse or partner, and the numbers of children in three age categories (0–5, 6–11, and 12–17 years.)

We used three measures of trauma and loss. The first was an indicator of whether the respondent's home experienced hurricane-related damage that was classified as being "moderate" or worse. The second was a trauma measure based on eight questions about experiences in the week following the hurricane: (1) not having enough fresh water to drink; (2) not having enough food to eat; (3) feeling like one's life was in danger; (4) lacking necessary medicine; (5) lacking necessary medical care for one's self; (6) lacking necessary medical care for family members; (7) lacking knowledge about the safety of children; and (8) lacking knowledge about the safety of other family members. These questions were based on items from a survey of Hurricane Katrina evacuees

conducted shortly after the hurricane (Brodie et al., 2006). The scale is a sum of the number of traumas experienced. The third was an indicator for whether a family member or friend of the respondent died as a result of Hurricane Katrina. These three measures were based on information collected in the second follow-up.

## Analyses

All analyses were conducted using version 11.1 of Stata. We documented changes in the prevalence of PTSS, PD, and combinations of PTSS and PD. We tested whether there were statistically significant changes in the occurrence of PTSS and PD between the two follow-up surveys.

We estimated multinomial logit models for each of the two time periods, to examine how pre-hurricane socioeconomic and health characteristics and hurricane experiences are related to the risk of having PD alone, PTSS alone, or PD and PTSS, relative to a base case of having neither PD nor PTSS. Small numbers of the observations had missing values for social support, earnings and the K6 at baseline. Rather than exclude observations with missing values, we filled in missing values used multiple imputations methods (i.e. the "mi" procedure in Stata), setting the number of replications to 100 (Rubin, 1996; Stata, 2009).

Next, we estimated multinomial logistic regression models that related pre-hurricane characteristics and hurricane experiences to the likelihood of experiencing transitions between categories of mental health states. We tested whether higher socioeconomic status and better mental health before the hurricane were associated with faster recovery, and whether some hurricane experiences delayed recovery more than others. We also examined how hurricane experiences differentially influence trajectories of PD and PTSS.

## Results

Table 1 provides descriptive information on the explanatory variables used in our analyses. The first column shows sample means and, where appropriate, standard deviations for the analysis sample. The second column shows means and standard deviations for baseline variables using a sample of the 942 women who enrolled in the study minus 19 respondents who were known to have moved away from New Orleans before August of 2005. The means for the full sample differ from those of the analysis sample for only one variable, suggesting that sample attrition is unlikely to bias our results. We examined whether our results were robust to the use of sampling weights designed to account for attrition, and found that weighting made very little difference to the results. Unweighted results are reported below.

The respondents had an average age of 26 years at the time of the hurricane and were predominantly African-American (84%). The majority of non-African-Americans were non-Hispanic whites. There were too few members of other racial ethnic groups to warrant distinguishing between non-Hispanic whites and members of other groups in the regression analyses. We do not include education among our covariates, because all participants in the study had to have a high school degree or a GED (General Education al Development certification) at the time they enrolled in the study. Given the income requirements in the Opening Doors study, it is not surprising that earnings before the hurricane were low, with an average of \$947 per month. Even so, there was still substantial variation in earnings across respondents. All respondents were mothers. At the time of the hurricane, the average number of children ages 0 to 17 living with the respondent was 1.9, and all but 8 respondents lived with at least one child. Only 35% lived with a spouse or partner.

PD was high before the hurricane (24% with K6 > 7.) This rate exceeds the 16% found for a representative sample of Gulf Coast

**Table 1**  
Descriptive statistics for analysis sample.

	Analysis sample ( <i>n</i> = 532)	Full sample ( <i>n</i> = 923)
Time from hurricane to first follow-up (SD), months	11.40 (2.92)	
Time from hurricane to second follow-up (SD), months	45.39 (2.58)	
Age at time of Hurricane Katrina (SD), years	26.18 (4.57)	26.32 (4.54)
Race, %		
Non-African American	16.5	16.8
African American	83.5	83.2
Monthly earnings at baseline (SD), \$	957.0 (497.5)	971.7 (496.3)
Social support at baseline (SD), 1 to 4 scale	3.22 (0.45)	3.19 (0.45) <sup>a</sup>
PD at baseline %	23.8	23.5
Not married or cohabiting at time of hurricane, %	64.8	
Children ages 0 to 5 at time of hurricane (number)	1.05 (0.83)	
Children ages 6 to 11 at time of hurricane (number)	0.58 (0.79)	
Children age 12 to 17 at time of hurricane (number)	0.30 (0.62)	
Home damaged during Hurricane Katrina, %	80.8	
Hurricane Katrina traumas (SD), 0 to 8 scale	2.93 (2.19)	
Relative or friend died as a result of hurricane, %	32.1	

Notes: Missing values in analysis sample: social support (19); earnings (62); and baseline psychological distress (19).

<sup>a</sup> Test that mean for the full sample is equal to the mean for the analysis sample is rejected,  $P = .042$ .

residents from the National Co-morbidity Survey who were assessed before Hurricane Katrina (Kessler et al., 2006). This difference may reflect the characteristics of our sample. A previous study indicates that women, as well as men and women with low socioeconomic status, are more likely than others to have PD as measured by the K6 (Bratter & Eschbach, 2005).

Respondents experienced significant levels of trauma and loss as a result of Hurricane Katrina: 81% had damaged homes; the average number of traumas was 2.9; and 32% had a family member or friend who had died as a result of the hurricane. The fraction of people who reported deaths may seem high, given that most estimates place the official death toll from the storm for Louisiana at about 1500 people (Beven et al., 2008). However, the majority of these deaths were of people who resided in the City of New Orleans. Deaths were concentrated in the 4th and 9th wards, where 20% of our respondents had lived (Jonkman, Maaskant, Boyd, & Levitan, 2009). Many respondents listed those who had died as grandparents, great grandparents, great aunts or uncles, and “elderly neighbors,” which is consistent with the fact that elderly people were at particularly high risk of death during the hurricane (Brunkard, Namulanda, & Ratard, 2008). Respondents may also have attributed some deaths to the hurricane that would not have been included in a medical examiner’s count.

Table 2 presents information on the prevalence of PD, PTSS and combinations of PD and PTSS across the two surveys. Information is also included on probable serious mental illness (SMI), for comparability with other studies of Hurricane Katrina (Kessler et al., 2008, 2006). PTSS declined from 45% to 33% between the first and second follow-ups, a statistically significant difference. PD experienced a smaller decline, from 36% to 30%. PTSS and PD frequently co-occur: at the first follow-up, 68% of those with PD also had PTSS, and 53% of those with PTSS also had PD. Almost all

**Table 2**  
Psychological distress (PD) and post-traumatic stress symptoms (PTSS) at first and second follow-ups, including PTSS in combination with probable serious mental illness (SMI).

	First follow-up	Second follow-up	Change	Chi-square test, <i>p</i> -value
PTSS, with or without PD, %	45.4	32.7	–12.7	0.000
PD, with or without PTSS, %	35.5	29.7	–5.8	0.043
SMI, with or without PTSS, %	12.6	10.0	–2.6	0.175
PTSS and PD combinations, %				
Neither PTSS nor PD	43.2	53.6	10.4	0.000
PD alone	11.3	13.7	2.4	
PTSS alone	21.2	16.7	–4.5	
PTSS and PD	24.3	16.0	–8.3	
PTSS and SMI combinations, %				
Neither PTSS nor SMI	52.6	63.7	11.1	0.000
SMI alone	1.9	3.6	1.7	
PTSS alone	34.8	26.3	–8.5	
PTSS and SMI	10.7	6.4	–4.3	

Notes: The fourth column shows *P*-values of chi-square tests of no change in distributions between first and second follow-ups. “PTSS” denotes an IES-R score greater than 1.5. “PD” denotes a K6 score greater than 7. “SMI” denotes a K6 score greater than 13.

those with probable serious mental illness at the first follow-up had PTSS. The combination of PTSS and PD declined 8.3% between surveys.

Although the prevalence of both PTSS and PD declined between the two follow-ups, some individuals experienced delayed reactions in the development of PTSS and/or PD: 19% of those who did not have PTSS at the first follow-up did so at the second follow-up, and 18% of those who did not have PD at the first follow-up did so at the second follow-up. However, the use of dichotomous variables to measure post-traumatic stress and psychological distress means that delayed responses can be produced by small movements in scores that cross the designated thresholds. Those who acquired PTSS had higher average values of the IES-R score at the first survey than those who did not acquire PTSS, and the average increase in their IES-R scores was smaller, in absolute value, than the average decline among those who recovered from PTSS. Similar patterns are evident for PD. This does not indicate that delayed responses are unimportant, but rather that they may frequently represent relatively modest changes in psychological functioning.

The results of the multinomial logistic regressions at the first follow-up (Table 3, Model 1) indicate that hurricane-associated home damage, trauma and loss had only small effects on PD alone (i.e. without PTSS). Although the relative risk ratio for hurricane traumas was 1.16 and marginally significantly different from 1.0, the hypothesis that the coefficients for damage, trauma and the death of a friend or relative were jointly insignificant could not be rejected ( $p$ -value = 0.16). Home damage and the death of a friend or relative increased the relative risk of having PTSS alone although, interestingly, hurricane traumas did not. The largest and most consistent effects of hurricane-associated trauma and loss at the first follow-up were on the combination of PTSS and PD. The relative risk of having both PTSS and PD was increased by 2.95 for those who experienced home damage, 1.25 for each additional hurricane trauma, and 2.76 for those who experienced the death of a relative or friend. The hypothesis that the effects of these variables on PTSS alone were the same as for PTSS and PD could be rejected ( $p$ -value = 0.005), implying that hurricane-associated home damage, trauma and loss increased the risk of developing both PTSS and PD more than they increase the risk of developing PTSS alone.

Hurricane-associated home damage, trauma and loss generally had larger effects at the second period than they did at the first (Table 3, Model 2). Home damage was associated with large

**Table 3**  
Relative risk ratios (RRRs) and standard errors (SEs), multinomial logit models of post-traumatic stress symptoms (PTSS) and psychological distress (PD).

	Model 1: First follow-up			Model 2: Second follow-up		
	PD alone	PTSS alone	PTSS and PD	PD alone	PTSS alone	PTSS and PD
Time to follow-up	1.05 (0.05)	1.00 (0.04)	1.00 (0.04)	0.97 (0.06)	0.98 (0.05)	0.80 (0.05)
Age at hurricane	1.00 (0.05)	1.08 (0.04)*	1.15 (0.04)***	0.97 (0.05)	1.04 (0.04)	1.10 (0.05)*
Baseline partnership status						
Married/cohabiting	1.00	1.00	1.00	1.00	1.00	1.00
Not married/cohabiting	0.60 (0.20)	1.03 (0.27)	1.02 (0.27)	1.01 (0.30)	0.94 (0.28)	1.36 (0.45)
Race						
Non-African-American	1.00	1.00	1.00	1.00	1.00	1.00
African-American	0.86 (0.33)	1.40 (0.50)	1.87 (0.76)	1.35 (0.53)	3.78 (2.14)*	1.23 (0.51)
Children ages 0 to 5	0.64 (0.14)*	1.12 (0.18)	0.92 (0.14)	0.95 (0.17)	1.06 (0.18)	0.84 (0.18)
Children ages 6 to 11	1.08 (0.28)	0.96 (0.15)	0.82 (0.14)	1.32 (0.27)	0.84 (0.16)	1.15 (0.22)
Children age 12 to 17	0.42 (0.14)*	0.96 (0.22)	0.58 (0.14)*	0.54 (0.21)	1.27 (0.29)	0.72 (0.21)
Baseline earnings (in logs)	0.90 (0.22)	0.77 (0.12)	1.00 (0.18)	1.35 (0.36)	0.66 (0.13)*	0.87 (0.20)
Baseline social support	0.53 (0.20)	1.32 (0.39)	0.63 (0.19)	0.50 (0.18)*	1.33 (0.42)	0.55 (0.23)
Baseline PD						
No	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.82 (0.68)	1.80 (0.56)	2.77 (0.83)**	1.83 (0.54)*	1.42 (0.48)	3.10 (1.06)**
Home damaged						
No	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.08 (0.39)	2.23 (0.77)*	2.95 (1.10)**	1.34 (0.49)	6.86 (4.05)**	3.65 (1.67)**
Hurricane traumas	1.16 (0.08)*	1.04 (0.06)	1.25 (0.07)***	1.18 (0.08)**	1.27 (0.08)***	1.64 (0.12)***
Relative/friend died						
No	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.30 (0.45)	1.82 (0.49)*	2.76 (0.71)***	1.80 (0.52)*	1.62 (0.45)	2.12 (0.65)*

Notes: Missing values of some covariates are imputed using multiple imputation methods. These include baseline earnings (62 observations imputed), social support (19 observations imputed) and baseline PD (19 observations imputed.)  $n = 532$ .

\* $P < .05$ ; \*\* $P < .01$ ; \*\*\* $P < .001$ .

increases in the relative risk of PTSS alone (RRR = 6.86) and in combination with PD (RRR = 3.65). Each hurricane trauma increases the relative risk of PD alone by 1.18, PTSS alone by 1.27, and PTSS and PD by 1.64. The death of a relative or friend was associated with greater risk of PD alone or in combination with PTSS. In contrast to the results from the first follow-up, the measures of hurricane-associated home damage, trauma and loss were jointly significant determinants of PD alone.

With a few exceptions, socioeconomic and demographic characteristics at or before the time of the hurricane were unrelated to post-hurricane mental health. The results indicate that older women were more likely to experience PTSS alone or with PD at the first follow-up, and PTSS with PD at the second follow-up; black women were more likely to have PTSS alone at the second follow-up; and the presence of young children and teens reduced the risk of PD at the first follow-up. Social support prior to the hurricane was associated with a reduced risk of having PD alone at the second follow-up, and women's earnings prior to the storm was estimated to be protective against PTSS alone at the second follow-up. Baseline PD has consistent effects on post-hurricane mental health: those with psychological distress prior to the hurricane were more likely to experience PTSS and PD at the first follow-up, and PD alone and PTSS and PD at the second follow-up.

We estimated variants of Models 1 and 2 using probable serious mental illness in place of PD, and found results that were qualitatively similar to those that used PD. Given the small numbers of individuals who had probable serious mental illness alone, the relative risk ratios for this outcome were not precisely estimated. Home damage, hurricane traumas and the death of a friend or relative were associated with increases in the risk of PTSS with probable serious mental illness.

We next estimated a multinomial logit model to assess how hurricane-associated factors influenced transitions between mental health states. Because there are two measures of mental health measured at two periods, there are sixteen possible categories in which individuals can fall. To simplify the model, we used

the fact that the hurricane-related variables were not associated with PD at the first follow-up, and collapsed the number of categories at the first follow-up to three: (1) No PTSS, (2) PTSS alone, and (3) PTSS and PD. This was crossed with four possible outcomes at the second follow-up: (1) No PTSS or PD, (2) PD alone, (3) PTSS alone, and (4) PTSS and PD, to produce a total of twelve categories. The results (Table 4) show only the relative risk ratios for the hurricane-related variables, although the other sociodemographic variables were also included in the model. The columns are labelled to denote categories that represent recovery, delayed onset, or chronic problems.

Several results from Table 4 are noteworthy. First, hurricane home damage, trauma and loss did not elevate the risk of developing and then recovering from PTSS, alone or in combination with PD (columns 1 and 2.) They also did not elevate the risk of transitioning from PTSS alone to PD alone (column 6). In fact, the hurricane-related variables are jointly insignificant for these three outcomes. This does not imply that hurricane-related variables had no effect on mental health, but rather that they increased the risk of experiencing delayed or chronic problems rather than increasing the risk of short-term problems that subsequently abated.

Second, hurricane home damage, trauma and loss did not elevate the risk of developing delayed PD (column 3). However those who experienced more hurricane traumas were at an elevated risk of developing delayed PTSS, alone or in combination with PD (columns 4 and 5). The death of a relative or friend was also associated with an increased risk of delayed PTSS and PD combined. It is interesting that home damage, which may be expected to produce long-run stress, is not associated with the delayed onset of psychological problems.

Although home damage did not predict delayed onset of psychological symptoms, it was associated with the probability of falling into all but one of the "chronic" categories. In fact, 100% of individuals who fall into three of these categories—PTSS in both periods, PTSS alone in the first period and PTSS with PD in the second, and PTSS with PD in the first and PTSS alone in the

**Table 4**  
Relative risk ratios (RRRs) and standard errors (SEs), multinomial logit model of transitions in post-traumatic stress symptoms (PTSS) and psychological distress (PD).

	No PTSS		PTSS only		PTSS + PD		PTSS only		PTSS + PD		PTSS + PD	
	PD only	delayed	PTSS only	recovered	PTSS + PD	delayed	PTSS only	chronic	PTSS + PD	chronic	PTSS only	chronic
Number in cell (%)	37 (7.0)	32 (6.0)	22 (4.1)	56 (10.5)	30 (5.6)	15 (2.8)	30 (5.6)	24 (4.5)	27 (5.1)	48 (9.0)		
Baseline PD												
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	2.10 (0.85)	1.39 (0.75)	3.93* (2.18)	1.15 (0.64)	2.11 (1.04)	2.78 (2.11)	3.33* (1.56)	2.36 (1.20)	2.01 (1.15)	5.33*** (2.22)		
Home damaged												
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.55 (0.74)	2.02 (1.17)	1.36 (1.00)	1.69 (0.68)	a	a	1.64 (0.95)	3.23 (2.39)	a	6.65** (3.92)		
Hurricane traumas	1.10 (0.11)	1.26* (0.12)	1.77*** (0.22)	1.00 (0.09)	1.22 (0.13)	1.37* (0.17)	0.97 (0.12)	1.36** (0.15)	1.46*** (0.14)	1.70*** (0.16)		
Relative/friend died												
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.10 (0.11)	0.57 (0.29)	3.16* (1.57)	1.46 (0.53)	3.45** (1.56)	1.27 (0.73)	2.14 (0.98)	3.21* (1.45)	3.97** (1.32)	3.31*** (1.32)		
Test: Hurricane	0.494	0.045	0.000	0.341	0.000	0.000	0.247	0.002	0.000	0.000		
variables jointly insignificant, p-value												

Notes: The base category for the multinomial logit is “No PTSS” at first follow-up and “No PTSS or PD” at the second follow-up. The base category contains 199 observation or 37.4% of the sample. Missing values of covariates are imputed using multiple imputation methods. Other variables included in model: time from hurricane to first follow-up, time from first to second follow-up, age at the time of the hurricane, whether unmarried/cohabiting at baseline, number of children by age category, baseline earnings, baseline social support. *n* = 532.  
a. All observations in this cell experienced home damage, producing large unadjusted coefficients and, after exponentiation, extremely large relative risk ratios (in excess of 1.0E+07).  
\**p* < .05; \*\**p* < .01; \*\*\**p* < .001.

second—experienced home damage, so that the unexponentiated coefficients on home damage are very large and the relative risk ratios approach infinity. Home damage was associated with more than a six-fold increase in the relative risk of developing chronic PTSS and PD. Hurricane traumas and the death of a family member or friend were associated with increased risk of experiencing a number of patterns of chronic problems.

**Discussion**

Recovery of mental health after Hurricane Katrina has been slow. Between 3.5 and 4.5 years (43 and 54 months) after the hurricane, nearly 30% of our sample had levels of psychological distress high enough to indicate probable mental illness. Although this represents a decline from the prevalence of 36% that was observed between 7 and 19 months after the hurricane, it is still substantially higher than the pre-hurricane prevalence rate of 24%. Symptoms of PTSS have also declined but remain high: the fraction of the sample with scores suggesting probable post-traumatic stress disorder was 33% between 43 and 54 months after the hurricane. Nearly five years after Hurricane Katrina, there continues to be a role for mental health services for survivors, especially those who experienced loss and trauma and have a history of mental health problems.

Our results using the K6 score can be compared to previous studies of the effects of Hurricane Katrina on mental health. The Hurricane Katrina Community Advisory Group conducted a representative survey of adults who lived in the Gulf Coast region at the time of the storm, and found that the prevalence of probable mild/moderate or serious mental illness (K6>7) barely declined from 44.3% between 4 and 7 months after the hurricane to 41.8% a year later (Kessler et al., 2008). Given that our sample consists of low-income women—people who should be at especially high risk of developing mental health problems after exposure to a disaster—it is surprising that these rates are higher than what we found at our first follow-up, which was conducted at roughly the same time as the second of the Community Advisory Group surveys. Our estimates are closer to those of Sastry et al., which surveyed individuals from New Orleans a year after the hurricane (Sastry & VanLandingham, 2009).

Our results provide evidence on the long-term effects of hurricane-related home damage, trauma and loss on the course of two mental health problems, PTSS and PD, and their co-occurrence. Our results indicate that hurricane experiences had different effects on the trajectories of PTSS and PD, alone and in combination. In general, hurricane stressors were more important predictors of chronic PTSS, with or without PD, but were less important for PD alone. Home damage greatly increased the risk of developing chronic PTSS, with or without PD. Fully 94% of those who had PTSS at the second follow-up had experienced home damage. However, we found that home damage was not a determinant of PD alone, in either the short run or long run. This is surprising because PTSS is usually associated with trauma rather than personal losses.

Our finding of the importance of home damage for PTSS but not for PD stands in contrast to results from a study of Hurricane Andrew, which concluded that symptoms of PTSD were more sensitive to within-disaster (traumatic experiences) than post-disaster stressors (Norris et al., 1999). Our findings also appear to be at odds with those of Sastry and colleagues who conclude that property damage was an important determinant of PD among individuals from New Orleans, measured approximately a year after the hurricane (Sastry & VanLandingham, 2009). However, this study does not measure symptoms of post-traumatic stress, and cannot distinguish PD alone from PD that co-occurs with PTSS, as we do. It may be that the effects of home damage on PD are

concentrated among those who also have PTSS. The importance of home damage for PTSS among individuals exposed to Hurricane Katrina may be due to the “secondary traumas” associated with the loss of community, the sometimes prolonged search for a new home, and the delays and uncertainties in government housing support for evacuees (Gill, 2007). These secondary traumas may have been more severe in the case of Hurricane Katrina, especially for low-income individuals.

Another conclusion is that the effects of exposure to traumatic events during the hurricane on mental health have not faded over time and, in some cases, have become worse. Those who experienced more hurricane traumas were at higher risk of developing delayed PTSS, with or without PD, and to develop chronic mental health problems. The death of a relative or friend was also associated with an increased risk of developing delayed PTSS and PD, or chronic problems involving various combinations of PTSS and PD. Although delayed responses are relatively rare, they have been observed in other studies of natural disasters. Hurricane Katrina produced such severe and long-lasting destruction that it may not be surprising that some individuals experienced deteriorations in mental health long after the hurricane. The general lesson of these results is that, although many individuals who experience PTSS and PD in the short run do recover, individuals exposed to trauma and loss continue to be at heightened risk of psychological problems long after the event is over.

We found that pre-hurricane socioeconomic status played a small role in protecting individuals from chronic mental health problems within this low-income sample. Higher earnings before the hurricane reduced the risk of PTSS at the second follow-up. Higher-earning individuals may have been better positioned to find employment after the hurricane or to afford the costs of rebuilding or resettlement. Having social support was protective against PD at the second follow-up. Somewhat surprisingly, we found that, at the first follow-up, adolescents were protective against PD alone and with PTSS. (Younger children were protective against PD, but this result was inconsistent over time and only marginally significant.) Most previous disaster research that examined the role of children compared parents to non-parents. Because all of our participants were parents, our results speak to whether the stress of having more children to care for during a disaster increases the risk of mental health problems for mothers. A previous study of Hurricane Katrina survivors found that greater numbers of children in a household predicted poorer mental health (Abramson et al., 2008). However, this study did not disaggregate children by age. It is possible that adolescent children are more self-sufficient and may have provided mothers with social support throughout the crisis and its aftermath. Finally, consistent with previous studies, we found that individuals who experience psychological distress prior to the hurricane were more likely than others to experience long-term psychological distress, with and without PTSS.

This study has several limitations. These include the non-representativeness of the sample, which could influence the results in unknown ways, and the use of self-report screening scales for PTSS and PD rather than clinical diagnoses of mental illness. In addition, the measures of trauma and loss associated with the hurricane were collected at the time of the second follow-up. It is possible that those who are more resilient or whose mental health recovered were less likely to report trauma and loss. Finally, the outcomes we assess are based on screening tools rather than clinical interviews. Although previous research has shown that high scores on the IES-R suggest probable post-traumatic stress disorder, and high scores on the K6 suggest probably mental illness, neither scale is a substitute for a clinical diagnosis.

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## Appendix. Supplementary material

Supplementary data related to this article can be found online at doi:10.1016/j.socscimed.2011.10.004.

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